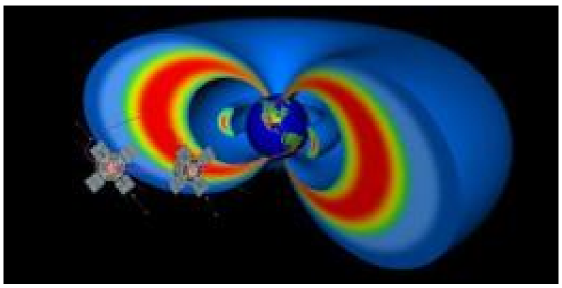
Launching balloons in Antarctica

February 23 2011



The two RBSP spacecraft will help study the Van Allen Radiation belts that surround Earth. Credit: Johns Hopkins University Applied Physics Laboratory

They nicknamed it the "Little Balloon That Could." Launched in December of 2010 from McMurdo Station in Antarctica, the research balloon was a test run and it bobbed lower every day like it had some kind of leak. But every day for five days it rose back up in the sky to some 112,000 feet in the air.

Down on Earth, physicist Robyn Millan was cheering it on, hoping the test launch would bode well for the success of her grand idea: launches in 2013 and 2014 of 20 such balloons to float in the circular wind patterns above the South Pole. Each balloon will help track electrons from space that get swept up in Earth's magnetic field and slide down into our atmosphere. Such electrons are an integral part of the turbulent magnetic space weather system that extends from the sun to Earth.

A professor at Dartmouth College, Millan is the principal investigator for a project called BARREL, or Balloon Array for RBSP Relativistic Electron Losses. Millan's proposal will work hand in hand with NASA's Radiation Belt Space Probes (RBSP) mission, two NASA spacecraft due to launch in 2012 to study a mysterious part of Earth's magnetic environs called the Van Allen radiation belts. The radiation belts are made up of two regions, each one a gigantic donut of protons and electrons that surrounds Earth.

"We're both looking at the loss of particles from the radiation belts," says Millan. "RBSP sits in space near the equatorial plane and looks at the particles along magnetic field lines there. These particles come into our atmosphere – following magnetic field lines to their base at the Poles – and produce X-rays. BARREL measures those X-rays. Together we can combine measurements of the same set of particles."

Figuring out what causes this rain of electrons will do more than simply improve understanding of the physics behind what drives such high-energy particles. The charged particles within the radiation belts can damage sensitive electronics on spacecraft like those used for global positioning systems and communications, and can injure humans in space. (The electrons don't make it all the way to Earth, so pose no danger to those of us on the ground.) Experiments like BARREL and RBSP help us understand the processes and mitigate those risks.

Millan began working on balloons during her graduate work at University of California, Berkeley, where she studied physics. She worked on a balloon called MAXIS that focused on electron precipitation from the magnetosphere into the ionosphere. "Then," she says, "We got this idea. They launch these huge payloads in Antarctica, but before that they send up smaller test balloons to make sure conditions are right for the big launch. And we thought – what if you could put instruments on those? So we took our payload, and miniaturized it."

She and her team, which includes scientists and students at UC Berkeley, UC Santa Cruz, and University of Washington, set about making payloads that weigh only 50 pounds for balloons that are some 90 feet in diameter. That still sounds fairly big unless you know that the typical balloons launched in Antarctica are the size of a football field and carry payloads of some 3,000 pounds. The team received funding from the National Science Foundation to fly a total of six small balloons in 2005, and shortly thereafter she learned that NASA had put out a call for experiments to support RBSP.

David Sibeck, the project scientist for RBSP at Goddard Space Flight Center in Greenbelt, Md., recalls that Millan's project proposal was well-tailored to RBSP's goals. "One of RBSP's main challenges will be to differentiate between the hordes of theories that try to explain why the belts wax and wane over time," Sibeck says. "The RBSP spacecraft will be equipped to distinguish between different options, but Millan's balloons have an advantage in one specific area: they can measure particles that break out of the belts and make it all the way to Earth's atmosphere."

The first test of BARREL -- funded by NASA and also supported by NSF's Office of Polar Programs that supports logistics of all research in Antarctica -- began in December of 2008. The final one began this past winter, when Millan left New Hampshire for Antarctica on Nov. 15. She arrived in McMurdo Station – after a transfer in Christ Church, New Zealand and a day lost due to crossing the date line – on Nov. 19. This flight needed to test travel and ease of launch capabilities as much as anything else, so Millan's team had shipped all the balloons ready to fly. Once in Antarctica, she and her colleague, Brett Anderson, a Dartmouth graduate student, got to work unpacking.

"It was great," she says. "We just had to pull them out of the box and turn them on. We mounted their solar panels and with just two people we were able to get things ready really fast, which isn't always the easiest thing to do when in Antarctica."

One reason to do such electron research at the Poles is that Earth's magnetic field lines touch down there. But equally important for this campaign are the slowly circling wind patterns that set up each summer. The BARREL project will release another balloon every 1-2 days and each should fall into line, consistently buoyed by the winds along the same circular path.

This past December – which is, of course, the summer in Antarctica – it took longer than normal for those winds, known as circumpolar winds, to set up. So when the first balloon was launched – a process spearheaded by the Columbia Scientific Balloon Facility -- it floated straight North towards Tasmania. This was the balloon that came to be known as The Little Balloon That Could, says Millan: "Perhaps it had a very small hole, but it didn't quite make it as high as it was supposed to – some 120,000 feet. It only ever got to 112,000 feet, but it maintained that height doggedly and even sent back some interesting data as it flew through an X-ray aurora." A second balloon did hit the right wind current, successfully transmitting data. (The second balloon did, however, have to be cut down a little early due to an overheated battery.)

So now the BARREL team will begin work on preparing the real show – two campaigns of 20 balloons each that will be launched during the 2012 to 2014 time frame.

"Her balloons will work in conjunction with RBSP," says Sibeck. "She can let us know if they're seeing particles and RBSP can look for the events that might be scattering them out of the radiation belts down to Earth." In addition, since each balloon is meant to stay aloft for 10 days, they will cover a huge area in the sky. When RBSP spots an interesting phenomenon, BARREL can give feedback over a large area as to where the particles went. The team will be able to see how big that region is and measure the total amount of particles that get kicked out of the belts – and thus determine how big of an effect different phenomena have. "That's something we would have more trouble doing with the spacecraft," says Sibeck.

Once each balloon is launched it moves slowly by floating in the wind. Those on the ground cannot control it, other than the single command to terminate the mission. A small explosive detonates and cuts the cable to the payload, which then floats down to the ground on a parachute. This was the fate of the two test balloons in December 2010, though they were particularly sorry to cut down the Little Balloon That Could. "We really wanted to see how far it would go," says Millan. "But it was so far north that we were getting close to Australian air space and we had to cut it down."

So the team declared the test a success, packed up their gear and began the long trip home to New Hampshire to oversee the building of 45 more payloads.

Provided by NASA's Goddard Space Flight Center